INDOOR AIR QUALITY ASSESSMENT

Department of Veterans' Services
239 Causeway Street, 1st Floor
Suite 100
Boston, Massachusetts

Prepared by:
Massachusetts Department of Public Health
Bureau of Environmental Health Assessment
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Background/Introduction

In response to a request from Dick Spicer, Department of Veterans' Services (DVS), an indoor air quality assessment was done at the DVS first floor offices at 239 Causeway Street, Boston, Massachusetts. The assessment was conducted by the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health Assessment (BEHA) and was prompted by reports of water damage to building materials and mold concerns. These concerns were related to a pipe in the sprinkler system that had burst on Friday, January 24, 2002.

On January 31, 2003, a visit was made to the building by Michael Feeney, Director of Emergency Response/Indoor Air Quality (ER/IAQ), BEHA to conduct an indoor air quality assessment. Mr. Feeney was accompanied by Mr. Spicer. The building at 239 Causeway Street is a five-story brick building, originally built as a factory/ warehouse in the late 1800's. The DVS is located in Suite 100 on the first floor of the building. Suite 100 consists of office space. Windows are not openable.

Methods

Air tests for carbon dioxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor, Model 8551. Moisture content of water damaged materials was measured using a Delmhorst, BD-2000 Model, Moisture Detector.

Results

The DVS has a population of approximately 40 individuals on a daily basis. The tests were taken under normal operating conditions. Test results appear in Tables 1-3. Air samples are listed in the tables by location that the air sample was taken as appears on the floor plan.

Discussion

Ventilation

It can be seen from the tables that carbon dioxide levels were above 800 parts per million parts of air [ppm] in seventeen out of eighteen areas surveyed. These carbon dioxide levels indicate inadequate air exchange in these areas. Of note were offices that had carbon dioxide levels over 800 ppm that were unoccupied.

Ventilation is provided by a heating, ventilation and air conditioning (HVAC) system. Fresh air is introduced by a rooftop-mounted air-handling unit (AHU), and distributed to occupied areas via ductwork located in the ceiling plenum throughout the building. Flexible ductwork attached to the main duct delivers air via fresh air ducts. In an effort to facilitate airflow, heat pumps are located above ceiling tiles. Transfer air from the AHU is drawn directly into the heat pumps and delivered to work stations via ceiling-mounted air diffusers.

The ventilation system is controlled by thermostats. Thermostats have a fan switch, which can be set to either “auto” or “on”. The left switch controls the heating/air-conditioning units according to temperature settings located at the top of the thermostat. The right switch controls the fan, which distributes fresh air to specific areas via heat pumps. At the time of the assessment, switches were set to the fan “auto”, which deactivated heat pumps due to increased heat from equipment used to dry carpet, flooring and gypsum wallboard (GW) that were water saturated as a result of the burst pipe. In addition, building HVAC personnel reported that the fresh air intake equipment on the roof had broken down on the same day as the flood. Therefore, no fresh air was being delivered to the first floor. The fresh air intake equipment was reactivated and heat pumps were set in the "on" position while Mr. Feeney was assessing the first floor. Carbon dioxide levels rapidly dropped in selected offices (see Tables), indicating that fresh air was once again being introduced into first floor offices. With the fresh air intake equipment and heat pumps deactivated, normally occurring indoor air pollutants can build up and produce symptoms described by DVS personnel.

Exhaust ventilation is provided by draw of air through metal/plastic grates into a ceiling plenum, which returns air to the AHUs. This system uses the entire above ceiling space to draw air back to the AHU via ductwork.

To maximize air exchange, the BEHA recommends that both supply and exhaust ventilation operate continuously during periods of occupancy. In order to have proper ventilation with a mechanical supply and exhaust system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. It is recommended that HVAC systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994).

The Massachusetts Building Code requires a minimum ventilation rate of 20 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows in each room (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week based on a time weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information concerning carbon dioxide, see Appendix I.

Temperature measurements ranged from 72° F to 80° F, which were within or close to the BEHA recommended comfort range in all areas surveyed. The BEHA recommends that indoor air temperatures be maintained in a range of 70° F to 78° F in order to provide for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply. Please note that drying equipment, which uses heat, was in operation during this assessment. The operation of drying equipment would be expected to raise temperatures above the range normally found in the DVS.

The relative humidity in the building ranged from 21 to 26 percent, which was below the BEHA recommended comfort range for all areas. The BEHA recommends a comfort range of 40 to 60 percent for indoor air relative humidity. Relative humidity levels in the DVS would be expected to drop during the winter months due to heating. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a very common problem during the heating season in the northeast part of the United States. Please note that heat produced by drying equipment would reduce airborne water vapor levels, therefore artificially lowering relative humidity below levels normally found within the DVS.

Microbial/Moisture Concerns

DVS staff reported that the pipe burst resulted in water on the floor to a depth of several inches in the rear hallway and offices. At this depth, lower drawers of file cabinets and materials in boxes on the floor became saturated with water. Wall-to-wall carpeting and lower levels of wall covering materials were also under water.

Substantial efforts to restore the floor to a workable environment were made by building management and DVS personnel. Drying operations and pipe repair reportedly began the afternoon of the flood. Drying operations continued during the week up to the day of Mr. Feeney's assessment. Floor fans and dehumidifiers were in operation at the time of the assessment. While carpeting appeared to have been substantially dried out, the condition of some GW remains problematic.

Suite 100 was renovated in 1998, prior to occupancy by the DVS. GW was installed in many areas of the basement. Each section is held in place with drywall screws. GW was painted and covered with plastic coving at its base (see Picture 1). A flood remediation contractor removed the plastic coving from many sections of wall throughout Suite 100 (see Picture 2). The plastic coving is a water impermeable material. In order to assess whether carpeting and GW (particularly sections that were under coving) had dried, moisture content of these materials was measured and is listed in the Tables. Moisture content of GW was measured 12 inches above the floor using a Delmhorst, BD-2000 Model, Moisture Detector (see Picture 3). Moisture content of carpeting was measured in random areas or where floor buckling was noted. No carpeting had detectable moisture readings. A number of areas of GW continued to have elevated moisture concentration a week after the flood (see Tables), despite the best efforts to dry this material. Water saturated GW can support mold growth if it remains moistened. The American Conference of Governmental Industrial Hygienists (ACGIH) recommends that porous materials (e.g., GW) be dried with fans and heating within 24 hours of becoming wet (ACGIH, 1989). If porous materials are not dried within this time frame, mold growth may occur. Water-damaged GW cannot be adequately cleaned to remove mold growth. The application of a mildewcide (e.g. bleach solution) to moldy GW is not recommended. Bleach consists of sodium hypochlorite in a 5 percent concentration mixed with 95 percent water. The additional water added to the subsurface mold fuels a spurt in growth, which increases mold colonization of the GW. As a result, mold colonies appear on the surface of treated GW shortly after application of bleach (Burge, 1999).

Other Concerns

Two other conditions may also have contributed to reports of indoor air related symptoms by DVS staff. In an effort to dry the south offices of Suite 100, a floor fan was placed next to a photocopier (see Picture 4). Photocopiers can produce volatile organic compounds (VOCs) and ozone, particularly if the equipment is older and in frequent use. VOCs and ozone are respiratory irritants (Schmidt Etkin, D., 1992).

The operation of fans and other drying equipment can readily aerosolize normal environmental dust found in the office space. Dust can be irritating to the eyes, nose and respiratory tract.

It appears that the consultant hired to re-mediate the area following the flood used a deodorizer. The deodorizer was poured onto a corrugated plastic tray and was then placed near a floor fan to distribute the scent (see Picture 5). Deodorizers frequently contain VOCs that can be irritating to the eyes, nose and throat. The lack of ventilation, combined with drying operations, can cause these deodorizers to remain in the office environment and produce symptoms in exposed individuals. When combined, these factors can serve to exacerbate conditions leading to eye irritations and other indoor air quality/comfort complaints.

Conclusions/Recommendations

The rapid response to dry the offices with Suite 100 most likely prevented conditions to produce mold growth. In view of the findings at the time of this visit, the following additional recommendations are made to further improve indoor air quality:

1. GW should be removed in the areas indicated roughly one foot above the floor in the offices with positive moisture measurements (taken one week after flooding occurred) (see Tables).
2. Continue to operate The HVAC supply and exhaust system and heat pumps continuously during periods of occupancy independent of thermostat control (the thermostat "on" position).
3. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, continue to use a HEPA filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).
4. Move fan away from photocopier.
5. Discontinue use of deodorizers.

References

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Picture 1

Example of Plastic Coving At Base of GW Wall (MDPH Office)

Picture 2

GW With Plastic Coving Removed

Picture 3

GW With a Positive Moisture Measurement

Picture 4

Fan Next To Photocopier

Picture 5

Corrugated Plastic Tray Coated with Deodorizer

TABLE 1

Indoor Air Test Results – Department of Veteran Services 239 Causeway Street, Boston   January 31, 2003

Location	Carbon Dioxide (*ppm)	Temp. (°F)	Relative Humidity (%)	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Outdoors	527	37	62					
Hallway outside stairwell with burst pipe	761	70	31	0	N	Y	Y	GW moistened
Military War Records	860	72	23	3	N	Y	Y	GW moistened Coving not removed behind large filing cabinets
137	849	72	24	0	N	Y	Y	Door open
134	961	73	26	0	N	Y	Y	GW moistened Door open
138	939	73	25	0	N	Y	Y	Door open Ozone generator
133	922	76	24	1	N	Y	Y	GW moistened
141	1036	76	24	0	N	Y	Y	Door open
142	932	78	24	0	N	Y	Y	GW moistened Door open
143	990	80	22	0	N	Y	Y	Door open

*** ppm = parts per million parts of air**
CT = ceiling tiles

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 2

Indoor Air Test Results – Department of Veteran Services 239 Causeway Street, Boston January 31, 2003

Location	Carbon Dioxide (*ppm)	Temp. (°F)	Relative Humidity (%)	Occupants in Room	Windows Openable	Ventilation Intake	Ventilation Exhaust	Remarks
Reception, DVS	884	79	21	1	N	Y	Y	Floor slightly buckled
106	991	76	21	0	N	Y	Y	Door open
122	927	75	25	0	N	Y	Y	Door open
123	958	75	25	1	N	Y	Y	Door open
Intentionally left blank								
123, ten minutes after activation of fresh air supply	804	75	24	1	N	Y	Y	Carbon dioxide difference from first reading=-154 ppm
141, ten minutes after activation of fresh air supply	801	78	23	0	N	Y	Y	Carbon dioxide difference from first reading=-231 ppm
142, ten minutes after activation of fresh air supply	814	78	23	0	N	Y	Y	Carbon dioxide difference from first reading=-117 ppm

*** ppm = parts per million parts of air**
CT = ceiling tiles

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 3

Indoor Air Test Results – Department of Veteran Services 239 Causeway Street, Boston   January 31, 2003

Location	Carbon Dioxide (*ppm)	Temp. (°F)	Relative Humidity (%)	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
143, ten minutes after activation of fresh air supply	810	78	22	0	N	Y	Y	Carbon dioxide difference from first reading=-180 ppm

*** ppm = parts per million parts of air**
CT = ceiling tiles

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%